STEM Education Practices and Implications in U.S. Public Libraries: A Case Study of the Idaho Library Commission's STEM Education Project (Postprint)

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Abstract

[Purpose/Significance] Through a case study of the STEM education program of the Idaho Library Commission in the United States, this research provides reference for developing STEM education in Chinese public libraries. [Method/Process] Using web-based investigation methods, this study surveys the STEM education program of the Idaho Library Commission, analyzes its implementation status, summarizes its characteristics, and proposes recommendations for Chinese public libraries to develop STEM education. [Results/Conclusion] The study indicates that China can promote the in-depth development of STEM education in public libraries by establishing public library STEM education committees, embedding reading promotion into STEM education, fostering the integrated development of STEM education and maker education, emphasizing adult STEM education, and other related aspects.

Full Text

Preamble

STEM Education Practice and Enlightenment in American Public Libraries: A Case Study of the Idaho Commission for Libraries' STEM Programs

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Abstract: [Purpose/Significance] Through a case study of the Idaho Commission for Libraries' STEM education programs, this paper provides references for public libraries in China to implement STEM education. [Method/Process]

Using web-based investigation, this paper examines the implementation of the Idaho Commission for Libraries' STEM education programs, analyzes their characteristics, and proposes recommendations for Chinese public libraries. [Result/Conclusion] The paper suggests that China should promote in-depth development of STEM education in public libraries by establishing public library STEM education committees, embedding reading promotion into STEM education, promoting the integration of STEM education and maker education, and emphasizing adult STEM education.

Keywords: American public libraries; STEM education; enlightenment **Classification Number:** G251.3 **DOI:** 10.13266/j.issn.0252-3116.2020.10.015

STEM is an acronym for Science, Technology, Engineering, and Mathematics. This concept was first proposed by the U.S. National Science Board in the 1980s, aiming to break down disciplinary barriers and cultivate students' practical innovation abilities and interdisciplinary problem-solving skills, thereby providing more STEM talent to maintain America's leading position in global competition. Since then, STEM has attracted continuous attention from the U.S. government, which has issued a series of policies and bills to promote its advancement. In 2007, the America COMPETES Act codified STEM education into law, elevating it to an unprecedented level of importance [1]. Because STEM education emphasizes interdisciplinary integration in science and engineering while neglecting humanities and social sciences, American scholar G. Yakman proposed STEAM education, where "A" (Art) encompasses broad humanities and arts subjects, including social studies, language, physical expression, music, aesthetics, and performance [2].

Although schools are the primary venues for STEM education, students' time on campus is limited, making out-of-school STEM programs a necessary supplement for long-term, sustainable implementation. Research shows that high-quality out-of-school programs can stimulate public interest in STEM, enabling participants to acquire more knowledge and skills and increasing their likelihood of pursuing STEM careers [3]. Consequently, American out-of-school institutions such as public libraries, educational groups, enterprises, and communities have begun supporting STEM education. U.S. STEM education policies recognize public libraries as important institutions for STEM education. For instance, the report "Charting a Course for Success: America's Strategy for STEM Education," jointly released by the White House and the Committee on STEM Education, identifies public libraries as strategic partners [4]. The U.S. Department of Education's "STEM 2026" report refers to the collaborative network for STEM learning as "participatory, interconnected communities of practice," with public libraries considered members of this community [5].

Currently, American public libraries have made significant progress in STEM education practice, which has become normalized. A 2016 national survey of public libraries found that among 455 participating librarians, 29% reported their libraries "frequently" (more than once a month) conducted STEM education, while 26% indicated "once a month" [6]. American public library STEM

programs are diverse and varied. For example, the Maryland State Library collaborates with STEM Festival organizers to promote STEM education in public libraries, schools, and communities, creating dynamic spaces for STEM learning. The Missoula Public Library created "EmPower Place" within its partner Missoula Food Bank, a learning center offering science exhibitions, children's and young adult books, and literacy and STEM programming services. Massachusetts public libraries partnered with school libraries to launch the "Science Is Everywhere" program designed for elementary students and their families. The Cleveland Public Library's "Mean Green Science Machine" project aims to provide early exposure to various STEM topics for grades 2-7 students, fostering their identification with STEM careers.

Among numerous STEM education programs, the Idaho Commission for Libraries' (ICfL) STEM education program is particularly typical and representative. First, its content is diverse, currently implementing five sub-projects: NASA@My Library, Make It at the Library, Summer STEM From Your Library, Fun with Math & Science, and Teen Tech Week, comprehensively covering all STEM disciplines. Second, the program attracts many public libraries statewide. For instance, the "Summer STEM From Your Library" project involved 47 libraries in 2018, serving over 66,000 users [7][8]. Third, some subprojects have been held continuously for years and are expanding their influence. The "Make It at the Library" project, launched in 2013, has gained national attention for successfully integrating STEM and maker education, sharing experiences at major conferences such as Capitol Hill Maker Faire and Public Libraries and STEM [9]. As no research literature on this program exists domestically or internationally, this paper selects it as a case study. Based on project information and news reports published on ICfL's website under the "STEM PROGRAMS" section [10], combined with content posted by participating libraries on their websites and Facebook, this paper analyzes the program's implementation and summarizes its characteristics. It should be noted that since this paper focuses on STEM education practice in public libraries, other types of libraries participating in sub-projects are not investigated.

2. Research Status

Foreign scholars have conducted in-depth theoretical research on STEM education in public libraries, primarily covering four aspects: rationale, advantages, challenges, and strategies/recommendations.

Many studies have explored the rationale for public libraries as informal education institutions for STEM education, examining perspectives such as library missions, functions, and STEM learning ecosystem construction. The core mission of public libraries is to provide individuals and communities with access to knowledge, and implementing STEM education offers a pathway for public libraries to fulfill this mission in the internet era [11]. Within the STEM learning ecosystem, public libraries can serve as third spaces for STEM learning beyond homes and workplaces (or schools) [12], helping shape community life

and culture by providing free STEM education resources for everyone [13].

Public libraries possess distinct advantages over formal STEM education institutions. For example, STEM practice series in public libraries allow students to interact with peers, parents, and community members, creating shared experiences [14]. Children and adolescents can learn topics like robotics and archaeology that are unlikely to be covered in school classrooms [12]. They can play and find inspiration in a pressure-free environment without assessment or grading [15]. Public library STEM education also helps address equity issues in STEM education and narrow the "opportunity gap" [16].

Challenges facing public library STEM education have also received attention, primarily concerning funding, resources, teacher development, and curriculum design. For instance, collection development plays a crucial supporting role in STEM education, but the rapid obsolescence of STEM literature and libraries' funding shortages may prevent timely updates [17]. Librarians lack confidence in teaching STEM courses [6], and establishing collaborative relationships between librarians and STEM teachers, along with curriculum design, faces challenges including teachers' time constraints, lack of administrative support from schools and libraries, and the constantly changing nature of STEM curricula [18].

Scholars have proposed strategies and recommendations for public library STEM education. Regarding curriculum design, libraries should collaborate with school teachers to align library STEM education content with classroom instruction and integrate scientific concepts with daily life to stimulate student interest [19]. Before implementing STEM programs, libraries should assess community needs and resources and conduct effective marketing [20]. After implementation, program effectiveness should be evaluated, monitored, and tracked [21]. Public library STEM education should ensure accessibility and equity to guarantee participation by disadvantaged groups [21].

Research in this field in China has just begun. Zhou Jiagui analyzed the "STAR Net" project in American public libraries and proposed suggestions for creating social education activities suitable for Chinese public libraries [22]. Wang Yang introduced the STEAM courses offered by the Fayetteville Public Library based on its maker space [23]. Xie Shoumei et al. analyzed the STEAM concepts embodied in Shenzhen Library's maker education and services [24]. These studies show that specialized research on STEM education in Chinese public libraries is still lacking, with most discussions placed within the context of maker space services or maker education. No deeper analysis has been conducted on the forms and implementation pathways of STEM education in public libraries. Therefore, based on the observational perspectives and explanatory paths provided by existing theoretical research, this paper conducts an in-depth investigation of ICfL's STEM education program to provide beneficial enlightenment for Chinese public libraries.

3. The Idaho Commission for Libraries' STEM Education Program

ICfL was established in 2006 with a mission to help libraries across Idaho enhance their capacity to serve their communities and meet the evolving information needs of the state's citizens. The STEM education program is one of many initiatives ICfL implements to fulfill this mission. Libraries throughout the state participate by applying to implement various sub-projects and receive information, resources, training, and technical support from ICfL.

3.1 "NASA@My Library" Sub-project

"NASA@My Library" is a STEM education initiative launched by the ALA Public Programs Office in collaboration with the National Center for Interactive Learning at the Space Science Institute, the Pacific Science Center, Cornerstones of Science, and the Education Development Center. It aims to provide more STEM learning opportunities for library users nationwide, including regions and populations currently underserved by STEM education [25]. ICfL is one of 18 state library agencies partnering in this initiative, supporting public libraries statewide through two toolkits provided by the program.

The program operates as follows: Public libraries submit toolkit reservation applications through the ICfL website 3-4 weeks before activities begin. After ICfL approves the application, it ships the toolkit to the library free of charge and adds the library's information (name, address, contact details of the person making the reservation, etc.) to a "reservation calendar" on the website for local residents to learn about and for other libraries to reference when making reservations. Participating libraries have a two-week usage period for the toolkit and sign a usage agreement that includes promoting the activity, completing a survey after the event, filling out an inventory form when returning the toolkit, and returning the toolkit on time.

With guides, accompanying teaching materials, and reusable equipment provided in the toolkits, public libraries can conduct diverse STEM education activities (see Table 1). The "Sun-Earth-Moon" toolkit helps participants understand their position in space and the influence of the sun and moon on Earth. The "Become a NASA Detective—Expand Your Senses" toolkit helps participants better use scientific tools and make predictions based on their observations. The ICfL website provides videos introducing the overview of both toolkits, briefly presenting the included tools and possible activities. Additionally, the website offers more detailed instructional videos for main activities, covering activity procedures, equipment usage, venue arrangements, and other details.

3.2 "Make It at the Library" Sub-project

In 2013, ICfL launched the "Make It at the Library" sub-project to provide necessary resources and training for library maker space construction to support

STEM-based educational activities. In the first year, all five pilot libraries achieved beyond-expected results, attracting numerous youth and families [26]. Since then, ICfL has continuously admitted new member libraries each year. To advance the project's development, ICfL has adopted the following measures:

(1) **Encouraging experience sharing among participating libraries.** The 2019 "Maker Faire" regional training meeting promoted best practice cases from 10 libraries, including Coeur d'Alene Public Library, to other participating libraries (see Table 2). Libraries shared creative ideas and main experiences in conducting STEM education through maker activities. For example, Payette Public Library promoted the "Cardboard Chair" activity, which uses project-based collaborative learning, allowing students to design and create using materials beyond cardboard and guiding them to think about the impact of different materials in industrial design. Burley Public Library promoted the "Candy Launcher" activity, where students use popsicle sticks, plastic spoons, rubber bands, and other materials to create launchers based on open-ended questions. Through discussion, they understand the relationships between angles, wheelbase, speed, and force to improve their creations, integrating science, technology, mathematics, and other knowledge through engineering problems.

(2) **Encouraging participating libraries to make full use of collection resources to create maker toolkits.** Several participating libraries combine collection resources (books, magazines, DVDs, etc.), online resources (websites, video tutorials), and physical objects to develop "Make It, Take It" toolkits for user borrowing. With equipment provided in the toolkits and by scanning QR codes to access accompanying books and digital resources, users can conduct maker activities outside the library and receive STEM education. ICfL shares on its website over 50 themed toolkits developed by Bear Lake County Library and Meridian Library, including activities such as "Papermaking," "Solar Robots," "Cake Decorating," "Potato Clocks," and "Bicycle Repair." This initiative fully utilizes libraries' collection advantages without limiting STEM education to within library walls, greatly increasing activity flexibility.

3.3 "Summer STEM From Your Library" Sub-project

The "Summer STEM From Your Library" project aims to support libraries in promoting STEM education during summer vacation. Its objectives include: providing more interesting, engaging, and practical STEM activities for youth in educationally underserved areas; increasing youth opportunities to read books during summer; and helping youth slow down summer learning loss. To achieve these goals, ICfL has adopted three major initiatives:

(1) **Multi-party collaboration.** The project receives funding from the Idaho STEM Action Center, which provides participating libraries with $600 grants to purchase books, equipment, or hire speakers for

activities. Simultaneously, participating libraries can collaborate with other organizations. For example, Salmon Public Library co-hosted a "Summer of Code" event with Khan Academy, offering programming introductory courses for grades 2-12 students. Falls Public Library partnered with a local Broadway Arts Center to introduce art courses into STEM activities. Kuna Library collaborated with the local non-profit educational organization RISE to provide free lunches and books for participating youth.

(2) **Internal-external linkage.** ICfL requires participating libraries to hold about half of their activities outside the library to expand project influence and broaden the connotation of STEM education. For example, Kamiah Community Library held an outdoor maker camp at a local elementary school featuring electronic greeting card design and soap making activities. Boise Basin District Library organized youth fishing trips at local ponds to connect with nature. Cascade Public Library offered free rafting opportunities for youth who participated in summer STEM activities throughout the program. In-library activities can be conducted according to textbooks compiled by ICfL for the project, covering all STEM disciplines, such as "Mentos and Soda" (science), "Data Packet Transmission" (technology), "Fishing Rod Pulley Devices" (engineering), and "Geometric Wood Block Assembly" (mathematics). The textbooks focus on explaining each activity's teaching objectives and related knowledge points, compiling scientific concepts involved in each activity into vocabulary lists (e.g., "energy," "gaseous state") to help learners build STEM vocabulary.

(3) **Summer reading.** Ensuring youth continue learning during summer vacation is an effective method to address "summer slide," and improved reading ability also lays a solid foundation for learning STEM skills. Therefore, ICfL encourages participating libraries to conduct summer reading activities integrated with STEM learning. For example, Ada Community Library designed "Summer Reading Log Cards" for children, teens, and adults. Readers who complete designated reading volumes and participate in activities on the cards can select free books from the library. Activities include making rockets with soda bottles, reading a book about the solar system, and constellation observation and identification.

3.4 "Fun with Math & Science" Sub-project

"Fun with Math & Science" is a STEAM education program for preschool children. Through workshops that invite parents and children to participate together in reading, games, and other activities, the program provides children with opportunities to create, design, explore the world around them, and solve problems, helping them master early math and science skills through "play." ICfL provides participating libraries with books, STEAM tools, activity manuals, online games, and other resources. Workshops are mainly conducted in three forms: storytime, small games, and family learning.

(1) **Storytime.** Storytime integrates math and science knowledge into stories, combining STEAM and literacy instruction. For example, North Bingham County Library held a "Jingle Bells" storytime during Christmas, explaining Santa Claus stories to children and guiding them to make bells to understand the principle of vibration sound production. Boise Foothills District Library organized children to read popular science books about the heart on Valentine's Day, learning concepts like heartbeat and rhythm, and helped parents find their children's pulse for observation before dancing together to feel pulse changes.

(2) **Small games.** Using tools and materials provided by the library, parents and children can experience the fun of "learning through play" in parent-child interactions. For example, Boise Collister District Library organized a "Human Body STEAM" activity where parents and children could explore human body mysteries at different "STEAM stations," such as skeleton building, brain region coloring, and organ arrangement. St. Mary's Public Library's "Math & Science Workshop" established five hands-on practice stations for parents and children with themes including insects, the solar system, magnet exploration, and DIY clay.

(3) **Family learning.** Parents are children's first teachers, and home is an important learning place. ICfL developed an online board game embedding URLs of quality children's websites, allowing parents and children to conduct science experiments and play math and puzzle games at home with a mouse click. Additionally, each workshop family receives a free copy of "101 Great Science Experiments" provided by ICfL, enabling parents to continue helping children learn math and science knowledge beyond the library.

3.5 "Teen Tech Week" Sub-project

Teen Tech Week (TTW) is a national initiative launched by the Young Adult Library Services Association (YALSA), primarily targeting teens, parents, educators, and other related personnel. Its purpose is to promote youth utilization of library e-books, e-readers, databases, audiobooks, and other non-paper resources, ensuring youth become qualified and ethical digital media users [27]. TTW began in 2007 and is held during the second week of March each year. Public libraries nationwide can register to participate through the activity website and freely download toolkits, promotional posters, logos, and other resources provided by YALSA. ICfL actively promotes TTW in Idaho through "online + offline" methods, inviting technical experts and youth services librarians to provide training for participating libraries. Training content adjusts according to TTW's annual themes. For example, the 2011 theme "Mix & Mash @ your library" encouraged youth to use library resources to create their own online content, so training courses included short video shooting and editing techniques for librarians to share with youth during Tech Week. The 2014 theme "DIY @ your library" focused on maker activities and discussed how libraries could

strengthen community partnerships and evaluate activity effectiveness and impact. Each participating library designs its own activities. Table 3 summarizes representative Idaho public libraries' TTW implementation over the past five years (2014-2018, as YALSA decided to reimagine TTW and suspended the 2019 event).

As shown in Table 3, although annual themes vary slightly, they all reflect the vision of using libraries as intermediaries to connect youth with technology, emphasizing the integration of games, competitions, and lectures into activities. For example, Caldwell Public Library's LEGO building competition includes a LEGO video game group, while Garden City Public Library invited film special effects artists to share experiences in film prop production and special effects techniques with youth, achieving the purpose of edutainment. Additionally, ICfL organizes evaluations of each library's activity plans and awards prizes to winners.

4. Characteristics of the Idaho Commission for Libraries' STEM Education Program

4.1 Reflecting Equity, Diversity, and Inclusion in STEM Education

The comprehensive development of STEM education depends on all members of society having equitable access to it. However, many studies show that differences in race, gender, region, and socioeconomic status cause disparities in STEM education access and STEM career pursuit. According to the latest National Science Foundation survey, while women earn STEM bachelor's degrees at rates comparable to men, their concentrations are in psychology and biology, with only about 20% in engineering and computer science. Additionally, minorities including Black or African American, Hispanic or Latino, and American Indian or Alaska Native individuals are employed in STEM fields at rates far below their representation in the U.S. population [28]. Therefore, promoting educational equity and improving STEM education accessibility for all groups has become a vision of U.S. STEM education. ICfL actively practices this concept to enhance equity, diversity, and inclusion in STEM education:

(1) **Networked layout.** ICfL advocates multi-party collaboration, emphasizing public libraries as centers to build cross-sectoral, multi-level, networked STEM ecosystems. Multiple sub-projects encourage participating libraries to extend STEM activities to families, schools, communities, and broader social environments rather than limiting them to library walls. Examples include the "Make It, Take It" toolkits in the "Make It at the Library" project that enable activities anywhere, family learning in the "Fun with Math & Science" project, and outdoor activities in the "Summer STEM From Your Library" project. Through extensive coverage of quality STEM education resources and full mobilization of social resources, ubiquitous and blended learning opportunities are provided for learners.

(2) **Diverse participation.** ICfL pays attention to the diversity of STEM learners. In the "NASA@My Library" project, ICfL requires participating libraries to explain how they enable disadvantaged groups such as ethnic minorities, impoverished populations, people with disabilities, and women to access activities and prioritizes delivering toolkits to libraries addressing this issue. Teaching materials compiled for the "Summer STEM From Your Library" project are available in both English and Spanish versions.

4.2 Establishing Project Tracking and Evaluation Mechanisms

To ensure STEM education quality and provide references for future project planning and support directions, ICfL requires participating libraries to complete online summary reports after activities for tracking and evaluation. Report content mainly covers four aspects: 1) Activity implementation survey, including time, location, format, and participation numbers; 2) Activity effectiveness feedback, such as whether the activity benefited the community and whether students could describe what they learned; 3) Project experience collection, including successes, lessons learned, and whether collaborations with community organizations were established, along with benefits and challenges; 4) Satisfaction survey of ICfL services, such as whether ICfL-provided resources met library needs and whether project implementation improved library services to the public, primarily using Likert scales for scoring. Additionally, participating libraries can provide opinions and suggestions on projects. This shows that ICfL's tracking and evaluation of sub-projects involves three levels—participants, projects, and communities—using point-and-surface combined evaluation for effective supervision of participating libraries during implementation while forming scientific evaluations of project planning to provide evidence-based support for future new project development and existing project improvement.

4.3 Emphasizing Teacher/Librarian Development

STEM education requires librarians to possess interdisciplinary comprehensive qualities, but librarians' academic backgrounds are often relatively singular. Therefore, strengthening librarian training and collaborating with professional teachers becomes an important guarantee for the sustainable development of public library STEM education.

ICfL introduces project overviews, service priorities, and explains activity design methods and ideas to librarians through on-site training and webinars. For example, the annual "Make It at the Library" project training meeting focuses on maker culture and how to use "Design Thinking" to bridge maker education and STEM education. The "Fun with Math & Science" project workshop guides librarians to provide STEM education for preschool children based on inquiry-based learning. These measures enhance librarians' understanding of STEM essence and STEM education literacy, strengthening libraries' capacity to implement STEM education. ICfL also provides resource recommendations

for participating libraries, collecting STEM education-related booklists, reports, blog articles, and case studies from other regional libraries on its website.

ICfL advocates collaboration with professional teachers and volunteers to address challenges of insufficient librarian capacity and limited energy. For example, in the "NASA@My Library" project, ICfL encourages participating libraries to invite volunteers from NASA's "Solar System Ambassadors" program to share the latest discoveries in space exploration with the public. In the "Summer STEM From Your Library" project, ICfL recruits part-time educators to promote activities at various parks, including reading to children, distributing books, organizing STEM activities, and collecting project data and information. Applicants submit resumes and position application statements via email, with requirements including having a driver's license, experience working with youth, and physical condition for outdoor summer activities. ICfL arranges interviews for qualified candidates, giving priority to applicants with STEM or library science backgrounds and bilingual abilities.

4.4 Encouraging Family Participation

Research shows that families' positive attitudes and joint participation help children succeed in STEM fields [29]. However, nearly one-third of parents lack confidence in their scientific knowledge and cannot guide children in scientific practice activities [30]. Many parents are unaware of after-school and summer STEM programs and cannot create life experiences that stimulate children's STEM interest [31]. As an important institution for STEM education, public libraries' open activities compensate for formal education system deficiencies. Parents can set examples and cultivate children's enthusiasm for STEM learning while accompanying them. ICfL's "Fun with Math & Science" project creates a collaborative learning atmosphere for parents and children through workshops, and many participating libraries in other projects also encourage family-unit participation. Through librarians' instruction and training, parents clarify their roles in children's learning processes, thereby conveying the value of STEM learning to children and promoting STEM practice.

4.5 Keeping Pace with STEM Education Trends

Since Professor G. Yakman proposed the STEAM concept, integrating Art into STEM education has become a consensus among many scholars. STEAM education emphasizes art's important role in stimulating students' imagination and creativity, which constitutes a basic element of innovation. For example, engineers need imagination to transform concepts into reality when designing products. Simultaneously, through art, students can more intuitively understand complex STEM knowledge, enhancing STEM learning appeal. ICfL keeps pace with the trend of STEM education transforming into STEAM education. Although its program name still uses "STEM," the concept of "STEAM" has appeared in sub-project planning. Influenced by this, participating libraries have appropriately strengthened the artistry of STEM education in service practice to

promote holistic human development. For example, Portneuf District Library designated Thursdays as “Art Days” during summer STEM education, with activities including “Solar System Necklaces,” “Straw Rockets,” and “Glow-in-the-Dark Paintings.” Activities such as “Book Trailer Production” and “Stop-Motion Animation Production” held during TTW also contain artistic elements.

5. Implications for STEM Education in Chinese Public Libraries

To better understand the current state of STEM education in Chinese public libraries, the author investigated the websites and WeChat official accounts of 31 provincial public libraries (excluding Hong Kong, Macao, and Taiwan) and searched for relevant online media reports using the keywords ”(STEM+STEAM)*library” on Baidu, Bing, and Google. These surveys show that many Chinese public libraries have launched STEM education activities. For example, Beijing Tongzhou District Library holds “Tech Sundays” for children and youth every week; Shanghai Library organizes youth programming activities during summer; Shandong Provincial Library offers “Children’s Science Public Classes Summer Camp” for children aged 7-10; Jinling Library provides astronomy, chemistry, engineering, and technology courses for children through its “STEM Series” courses. Guangzhou Haizhu District Library’s “STEM Popular Science Series Activities” include popular science lectures, exhibitions, reading, and parent-child activities. Although Chinese public libraries have actively explored STEM education, problems exist: unbalanced regional development with educational practice mainly concentrated in economically developed areas; courses mostly target children and youth with few for adults; insufficient curriculum richness with some libraries’ activities focusing only on one STEM discipline, making it difficult to promote students’ in-depth learning in STEM fields; many courses are single or short-term activities with poor continuity.

American public libraries have taken the lead in both theoretical research and practical exploration of STEM education. The 2015 “Public Libraries and STEM” conference further promoted STEM education development in American public libraries. ICfL’s STEM education program is a microcosm of this practical exploration and offers valuable references for Chinese public libraries.

5.1 Establish Public Library STEM Education Committees

The active implementation and remarkable effectiveness of STEM education in Idaho public libraries are mainly attributable to ICfL’s support and planning. The commission leads the implementation of various sub-projects, including self-designed projects and collaborative projects with organizations such as ALA, the Idaho STEM Action Center, and YALSA, providing substantial support to participating libraries in librarian training, resource supply, and funding while promoting project evaluation and experience sharing.

Currently, Chinese public libraries often act independently when conducting various activities, lacking overall planning and guidance from government agencies and professional organizations. If STEM education is also explored and promoted by each library independently, it will be detrimental to establishing a long-term mechanism for STEM education in public libraries. Therefore, considering China's national conditions and development status, public library STEM education committees should be established. The China Library Association could serve as the initiator, with library associations at all levels co-organizing, or provincial public library authorities could take the lead in establishing such committees to strengthen top-level design, project guidance, and resource support for STEM education, clarify the service positioning of STEM education in Chinese public libraries, and continuously promote the healthy development of STEM education in public libraries.

5.2 Integrate Reading Promotion into STEM Education

STEM learning requires good reading ability and the capacity to express complex scientific concepts clearly through oral or written forms. Therefore, libraries need to integrate reading with STEM teaching, which is particularly important for children and youth. In ICfL's "Make It at the Library" project, e-book resources accompanying toolkits; the summer reading activities in the "Summer STEM From Your Library" project; and storytime in the "Fun with Math & Science" project are all beneficial attempts by participating libraries to combine reading with STEM education. This is significant for learners to understand professional terminology and increasingly complex and interconnected concepts in future STEM field learning.

Currently, science and technology museums and other institutions in China are conducting science popularization education. How can libraries make STEM education distinctive and gain social recognition under these circumstances? The author believes that fully leveraging libraries' experience in reading promotion and organically combining reading promotion with STEM teaching is an important pathway. To this end, libraries can take three measures: 1) Recommend reading lists for learners based on STEM teaching themes; 2) Use visual, audible, and interactive digital reading such as AR books to enhance reading fun while cultivating learners' digital literacy; 3) Supplement with presentations, writing, and other segments, encouraging learners to share and record in STEM courses to comprehensively improve their listening, speaking, reading, and writing abilities.

5.3 Promote the Integration of STEM Education and Maker Education

With the widespread development of the maker movement in foreign libraries, Chinese libraries have also experienced a boom in maker space construction in recent years, combining maker culture with education to conduct maker education. However, comprehensive analysis shows that domestic libraries have not

yet formed mature and complete curriculum systems for maker education, with serious homogenization in teaching content that mainly emphasizes "creation" using digital tools like computers and 3D printers rather than emphasizing disciplinary knowledge. If maker education one-sidedly focuses on cool technology and only emphasizes small inventions and creations, it may become formalistic. For students who have not yet consolidated foundational disciplinary knowledge, the purpose of "play" is achieved, but the effect of "learning" is poor. STEM education, on the other hand, emphasizes mastery of interdisciplinary knowledge, encouraging students to integrate knowledge to solve real-world problems, but it insufficiently cultivates creativity. Thus, maker education and STEM education have inherent connections and can serve as a form of STEM education, but must embed STEM education concepts to achieve complementary advantages and promote integrated development.

ICfL's "Make It at the Library" project guides participating libraries to integrate STEM elements into maker activities through design thinking and introduces several design thinking operation models to librarians, such as the widely adopted EDIPT model proposed by Stanford University's d.school, which includes Empathize, Define, Ideate, Prototype, and Test [32]. From its promotion cases, participating libraries fully apply design thinking to curriculum design. Activities like "Balloon-Powered Cars," "Cardboard Chairs," and "Candy Launchers" integrate science, technology, engineering, mathematics, and other disciplinary knowledge, guiding students to develop empathy to identify problems and use STEM knowledge for concept development, design practice, and testing. When Chinese public libraries implement STEM education, they can learn from ICfL's practices by integrating STEM knowledge into maker activities, using design thinking as an activity guidance strategy to cultivate students' hands-on abilities and innovative thinking while enhancing their knowledge acquisition and application, ultimately achieving deep integration of STEM education and maker education.

5.4 Emphasize Adult STEM Education

According to the latest survey results released by the China Association for Science and Technology, the proportion of Chinese citizens with scientific literacy reached 8.5% in 2018, a significant increase over the past three years, but the overall level remains relatively low [33]. Undoubtedly, improving public scientific literacy will play an important role in China's building of a world science and technology powerhouse. As President Xi Jinping pointed out at the "Three Science Conferences" in 2016: Without the universal improvement of scientific literacy for all, it is difficult to establish a large high-quality innovation workforce and difficult to achieve rapid transformation of scientific and technological achievements. Although ICfL's STEM education program mainly targets children and youth, many participating libraries' activities are also open to adults, which aligns with the U.S. Department of Education's goal definition for STEM education programs: supporting and strengthening STEM learning from elemen-

tary school through graduate school while emphasizing adult STEM education [34].

Chinese public libraries should also actively attract adults to participate in STEM education, transforming the stereotype that STEM education only targets children and youth, making public libraries important informal STEM education institutions for adults. This can not only equip more adults with scientific thinking and STEM skills to improve their ability to identify "pseudo-science" and "anti-science" information but also promote their transformation of learned knowledge into powerful drivers for innovative development through learning and communication. Since adult learning styles differ, Chinese public libraries should pay attention to differences from child and youth STEM education when serving adults. First, since adults' brains are fully developed and they don't need to build new neural pathways when receiving new information but instead draw connections from existing thinking patterns, libraries should keep course content relevant to their interests and experiences, enabling better learning [35]. Second, since adults focus on learning practicality and instinctively pay more attention to things helpful to their lives [36], libraries should fully investigate adult learners' needs in their service communities, enhance STEM course appeal, and align content with real-life practice as much as possible, enabling them to practice STEM skills in daily life. Finally, since adults may be unable to come to the library for learning due to busy work and life, requiring more flexible learning methods, libraries can provide online courses and reading push notifications based on adults' strong self-learning abilities.

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Abstract: [Purpose/significance] Based on a case study of the Idaho Commission for Libraries' STEM programs, this paper provides reference for STEM education implemented in public libraries in China. [Method/process] Using Internet survey, this paper analyzed the implementation of the Idaho Commission for Libraries' STEM programs, and summarized its characteristics. On this basis, the study put forward suggestions for Chinese public libraries to carry out STEM education. [Result/conclusion] The corresponding suggestions include: establishing STEM education commission of public libraries; integrating reading and STEM education; promoting the integration of STEM education and maker education; emphasizing on adult STEM education.

Keywords: American public libraries; STEM education; enlightenment

Note: Figure translations are in progress. See original paper for figures.